Oceanic gabbro signature in Mangaia melt inclusions

R.A. Cabral[1]*, M.G. Jackson[1], E.F. Rose-Koga[2], J.M.D. Day[3], K.T. Koga[2], N. Shimizu[4], M.J. Whitehouse[5], A. Price[1]

[1]Boston University, Dept. Earth Sciences, Boston, MA 02215 (*correspondence: racabral@bu.edu)
[2]Universite Blaise Pascal, Laboratoire Magmas et Volcans, CNRS, UMR 6524, Clermont-Ferrand, France
[3]Scripps Institution of Oceanography, La Jolla, CA 92093-0244
[4]Woods Hole Oceanographic Institution, Woods Hole, MA 02543
[5]Swedish Museum of Natural History, Laboratory for Isotope Geology, SE-104 05, Stockholm, Sweden

Lavas from Mangaia exhibit an extreme HIMU (high-μ, or high $^{238}\text{U}/^{204}\text{Pb}$) signature that has been attributed to melting of ancient recycled oceanic crust within ocean island basalt (OIB) mantle sources [1]. In a landmark study, Saal *et al.* [2], measured extreme lead isotopic diversity in melt inclusions (MI) from Mangaia, spanning half of the global range observed in OIBs. In Pb-isotopic space, these MI display a trend towards an unradiogenic end member similar to MORB. However, the origin of Pb isotope diversity and the identity of the unradiogenic end member could not be resolved due to lack of coupled major-trace-volatile element abundances for the MI.

This study examines homogenized olivine-hosted MI in Mangaia lavas. We present the first coupled measurements of major-trace-volatile element abundances and Pb-isotopic measurements on the same MI. Critically, we identify Pb-isotopic variability in our MI, and Pb-isotopic ratios correlate with ratios of major, trace, and volatile elements. For example, the anomalous MI with MORB-like Pb-isotopic ratios exhibit geochemical signatures associated with oceanic gabbro, including elevated Sr/Nd, Ca/Al, Cl/La, and K/La.

It is difficult to constrain the origin—modern plate or ancient recycled lithosphere—of the gabbroic signature. One hypothesis is that the gabbroic signature in the MI derives from melting of the gabbroic section of ancient, recycled oceanic crust [3]. Alternatively, Saal *et al.* [4] suggested that a gabbroic signature in OIB lavas derive from shallow assimilation of gabbros during magmatic ascent. The primary difference between these two hypotheses is that the former requires gabbros processed in a subduction zone, and the latter does not. The elevated Cl/La and K/La in the anomalous melt inclusions is not consistent with subduction zone processing, as Cl and K are fluid mobile and should be lost from the down-going slab. By contrast, altered oceanic gabbros have elevated (Cl, K)/La. Based on the current dataset, we favor the hypothesis that the anomalous gabbro signature (and Pb-isotopic diversity) in Mangaia MI owes to assimilation of Pacific oceanic crust during magmatic ascent.

[1] Hofmann & White (1982) *EPSL* 57, 421-436. [2] Saal *et al.* (1998) *Science* 282, 1481-1484. [3] Sobolev *et al.* (2000) *Nature* 404, 986-990. [4] Saal *et al.* (2007) *EPSL* 257, 391-406.

Petrologic evidence for rapid exhumation of Alpine UHP rocks from > 100 km depth

Mark J. Caddick[1]*, Robert J. Tracy[1], Nancy L. Ross[1]

[1]Department of Geosciences, Virginia Tech, Blacksburg, Virginia, United States, caddick@vt.edu (* presenting author)

We report on a whiteschist from the Brossasco Zone in the Dora Maira UHP Alpine massif – a sample that preserves a remarkably well-constrained record of its late-prograde to peak pressure history, and allows exploration of the processes, mechanisms and timescales of burial and exhumation in rocks reaching ultra-high pressure conditions. Thermodynamic modeling suggests that the abundance and composition of the major phases (garnet, kyanite, Mg-phengite, phlogopite, Na-phlogopite, quartz/coesite, talc and rutile) are consistent with equilibration at ~ 3.5 GPa, 775 ˚C. Well-preserved palisades-textured quartz around large coesite inclusions in garnet attests to this high-pressure phase of the rock's history, whilst complete coe-qtz inversion during exhumation is reflected in the matrix. Unusual evidence of the path taken to reach maximum P and T can be inferred from asymmetric, high-Ca bands within pyrope-rich (~ prp_{92}) garnet. These bands, which mimic their host crystal's shape and contain ~ 3 times higher X_{gro} than the host, are sharply defined at their inner margin (towards the crystal core) but decay gradually to a low-Ca rim. We interpret this as fractionation of Ca from a finite matrix source during garnet growth. Thermodynamic constraints strongly indicate that the precursor host for this Ca was lawsonite, which is now entirely absent from the sample but helps to constrain the early heating history.

Indicators such as retained strain in matrix quartz crystals and sharp boundaries in garnet zoning profiles suggest that exhumation and cooling were very rapid. Diffusion modeling of garnet zoning yields best-fit timescales of ~ 5 Myrs, consistent with exhumation timescales previously inferred from isotope geochronology [e.g. 1]. This is corroborated by preliminary EMP dating of two monazite populations, which can be characterized as low-Y and high-Y bearing. High-Y rims are common on low-Y cores of matrix monazite but are absent from crystals present as inclusions in garnet, and are interpreted as representing growth during decompression-driven garnet breakdown. Initial results suggest that this rim growth occurred < 10 Myrs (and possibly closer to 5 Myrs) after prograde growth of the low-Y monazite cores.

The constrained pressure-temperature history, including rapid exhumation and an almost complete lack of retrogressive reaction (other than slight garnet breakdown to Mg-rich talc and kyanite) indicates possible mechanisms for burial, heating and exhumation. Likely exhumation rates approach rapid plate tectonic velocities, indicating that erosion was not a major controlling factor. Furthermore, thermodynamic models suggest that the Dora Maira sample had a density of ~ 3.2 g/cm^3 at 110 km depth, implying that despite the relatively small volume of preserved whiteschist material, buoyant exhumation back along a subduction channel remains a feasible mechanism.

[1] Rubatto & Hermann (2001) *Geology* **29**, 3-6.